melted mixture to form a solid feed material in the crucible, and then heating an upper portion of the feed material in the crucible with the upper heater to a temperature above the melting temperature of the material.

REMARKS

Claims 1-37 are pending in the application. Claims 1-12 have been withdrawn from consideration, however, Applicants respectfully request reconsideration of these claims, as discussed in more detail below. Claims 13, 21, 26, 29, 36 and 37 have been amended. Support for these amendment may be found throughout the specification, including, but not limited to, page 3, lines 25-27; page 9, lines 1-4; page 11, lines 24-26; and page 12, lines 6-8. The claim amendments add no new matter and are otherwise proper.

In view of the following remarks, reconsideration and withdrawal of the rejections to the application in the Office Action is respectfully requested.

I. Restriction Requirement

In the Office Action, the Examiner acknowledged Applicants' election with traverse of claims 13 through 37 of the pending application. However, the Examiner stated the arguments set forth against the restriction were not found persuasive because a serious burden exists in the differing issues likely to arise during the prosecution of the different statutory classes of the invention. Although claims 1-12 have been withdrawn from consideration, Applicants respectfully request reconsideration and withdrawal of the restriction requirement in light of the arguments set forth below.

A restriction requirement for closely related inventions is appropriate only in situations where there is either a separate classification or a separate status in the art for the inventions and a separate field of search is required. MPEP § 808.02. In the present case, the method and apparatus claims are so closely related that the pertinent art with respect to the method claims will also be the pertinent art for the apparatus claims. Therefore, the two sets of claims do not require a separate field of search. The extremely close relationship between the apparatus and method claims is illustrated by the fact that the structural elements recited in independent method claims 13 an 29 are also recited in independent apparatus claim 1.

Independent claims 13 and 29 are directed to methods for carrying out Czochralski crystal growth. The structural elements recited in claims 13 and 29 are *a crucible* for accepting a feed material, *an upper heater* for heating an upper portion of the crucible, and *a lower heater* for heating a lower portion of the crucible. In addition, claims 13 and 29 include the step of advancing the crucible with respect to the heaters, which suggests the need for some means of moving the crucible and/or heaters. Independent claim 1 is directed to an apparatus for carrying out Czochrolski crystal growth. The structural elements in claim 1 are *a crucible*, *an upper heater*, *a lower heater*, *heat insulation* between the upper and lower heaters and *an axially advanceable crucible support*. Therefore, the structural elements of the apparatus claim and the method claims overlap, although the method claims do not require the presence of an insulator between the upper and lower heaters. The presence or absence of an insulator cannot be considered sufficient grounds to require a separate field of search for the method and apparatus claims. Thus, based on the similarities between the structural elements in the apparatus and method claims, it follows that the pertinent prior art with respect to the method claims will also be the pertinent prior art with respect to the apparatus claims. Moreover, due to the similarities between the apparatus and method claims it is likely that the features that distinguish the methods of the present invention from the pertinent prior art references will be the same features that distinguish the apparatus of the present invention from those references. For these reasons, the search and examination of both sets of claims can be conducted without serious burden to the Examiner and Applicants respectfully request that the restriction requirement be withdrawn.

II. Rejection of Claims 13-37 Under 35 U.S.C. § 112, Second Paragraph

The Examiner rejected claims 21 and 37 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regard as the invention, alleging that it is unclear how "thoroughly mixing" differs from generic mixing. The amendments above have removed the word "thoroughly" from claims 21 and 37. Therefore, Applicants believe that these claims are not unclear and respectfully request that the Examiner withdraw the rejection.

The Examiner also rejected claims 13-37 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject

matter which Applicants regard as the invention, alleging that in the phrase "desired concentration" it is unclear how desired is limiting. Similarly, the Examiner rejected claims 26 and 36 under 35 U.S.C. § 112, second paragraph, as being indefinite because it is unclear how the word "desired" in the phrase "desired dopant" is limiting. In compliance with the Examiner's recommendation, the word "desired" has been removed from claims 13, 21, 26, 29, 36 and 37, by the claim amendments. Therefore, Applicants believe that these claims are not unclear and respectfully request that the Examiner withdraw the rejection.

III. Rejection of Claims 13, 14, 21-24, 27 and 28 Under 35 U.S.C. § 102(b)

In the Office Action, the Examiner rejected claims 13, 14, 21-24, 27 and 28 as anticipated by U.S. Patent No. 5,363,796, issued to Kobayashi, et al. (hereinafter "Kobayashi"). Applicants respectfully traverse.

In order for a reference to anticipate the claims of the pending application, that reference must teach each and every limitation of the rejected claims. Kobayashi fails to teach at least two of the limitations in independent claims 13 and 29. Namely, Kobayashi does not teach the step of providing a crucible with a solid feed material *comprising each of the constituents of the crystal to be grown*. Moreover, Kobayashi does not teach the step of heating an upper portion of a crucible with an upper heater to a temperature sufficient to melt the feed material in the upper portion of the crucible *while the feed material in the lower portion of the crucible remains solid*. Instead, Kobayashi teaches a method for growing a single crystal wherein only one component of the crystal to be grown, namely pure silicon, is charged into a crucible and melted. Once this pure material is completely melted, the bottom portion of that material is allowed to solidify. It is only after this bottom portion is solidified that the remaining constituents for the crystal to be grown, namely an N-type dopant, is added to the melt in the crucible. Therefore, the solid feed in Kobayashi does not contain each of the constituents of the crystal to be melted as recited in claims 13 and 29 of the pending application. Indeed, this distinction between the rejected claims and the teaching of Kobayashi is supported by the Examiner's own characterization of that reference. Specifically, in support of the rejection, the Examiner stated that Kobayashi,

> "discloses a double structure crucible with a crucible made of quartz placed inside a graphite crucible (col 7, ln 10-18).

> Kobayashi, et al. also discloses a main heater (32) and a subheater (33) facing the zone in which the crucible vertically moves and are vertically separated (col 7, ln 19-30) at the lower and upper portions of the periphery of the crucible (col 5, ln 27-35). . . . Kobayashi, et al. also teaches a raw material is charged into said crucible in an Argon (Ar) atmosphere and the main heater and subheater are activated so that all of the raw material is melt, then the output of the main heater is increased and the power of the subheater is decreased to grow the solid layer in the lower portion of the crucible, where after the solid layer becomes stable and stops growing, a N-type dopant is added (col 9, ln 10-25)."

Thus, by the Examiner's own admission, Kobayashi teaches a method wherein some of the constituents of the crystal to be grown are added to the melt during the crystal growth process rather than being present in the solid feed. In addition, by the Examiner's own admission, Kobayashi teaches a method for preparing a crystal in which a solid feed is initially completely melted followed by the solidification of the lower portion of the feed. This is in direct contrast to the methods recited in claims 13 and 29 of the pending application wherein the upper portion of a solid feed is melted while the lower portion of that feed remains solid.

Because Kobayashi fails to teach at least two of the claim limitations recited in independent claims 13 and 29 of the pending application, Kobayashi cannot anticipate these claims. For this reason, Applicants respectfully request that the Examiner withdraw the rejection.

IV. Rejection of Claims 15-21, 25, 26 and 29-37 Under 35 U.S.C. § 103(a)

In the Office Action, the Examiner combined several references with Kobayashi in order to support claim rejections under 35 U.S.C. § 103(a). First, the Examiner rejected claims 15-19, 29-35 and 37 under 35 U.S.C. § 103(a) as being unpatentable over Kobayashi in view of U.S. Patent No. 4,609,530, issued to Morioka, et al. (hereinafter "Morioka"). The Examiner also rejected claim 20 as being obvious over Kobayashi in view of German Patent Application No. DE 19615991 A1, issued to Abrosimov, et al. (hereinafter "Abrosimov"). Next the Examiner rejected claims 25 and 26 as being obvious over Kobayashi in view of the Journal of Crystal Growth, 193 (1998) pg. 443-445, authored by Lin, et al. (hereinafter "Lin"). Claim 36 was rejected as obvious over Kobayashi in view of Morioka and further in view of Lin.

Claim 21 was rejected as obvious over Kobayashi in view of U.S. Patent Nos. 4,013,501, issued to Van Uitert, et al. (hereinafter "Van Uitert"). Finally, the Examiner rejected claim 30 under 35 U.S.C. § 103 as being unpatentable over Kobayashi in view of Morioka and further in view of Van Uitert. Applicants respectfully traverse.

In order to establish a prima facie case of obviousness based on two prior art references, the references must teach each and every claim limitation in the rejected claims and there must be some suggestion or motivation to modify the reference or to combine reference teachings.

Each of the above-referenced rejections is based on the false assumption that Kobayashi teaches a method of carrying out crystal growth that includes the steps of providing a crucible with a solid feed material comprising each of the constituents of the crystal to be grown and heating an upper portion of the crucible in order to melt the feed material in the upper portion while the feed material in the lower portion remains solid, as recited in independent claims 13 and 29 of the pending application. As discussed in detail above, neither of these limitations is taught or suggested by the disclosure of Kobayashi. Nor are these limitations taught in any of the other references cited by the Examiner. Therefore, the cited references, alone or in combination, fail to teach each and every limitation of the rejected claims. For this reason, Applicants respectfully request that the rejection be withdrawn.

Applicants also note that even if one of the secondary references cited by the Examiner did teach those steps of claims 13 and 29 which Kobayashi fails to teach, it would be improper to combine those references because such a modification would change the principle of operation of the invention in Kobayashi. "If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious." MPEP § 2143.01. Applicants respectfully submit that modifying Kobayashi to include a solid feed that contains each of the constituents of the crystal to be produced would alter the principle by which the method of Kobayashi operates, and therefore cannot be the basis of prima facie case of obviousness under 35 U.S.C. § 103(a).

Kobayashi discloses an apparatus and method for growing a single crystal in which a melted layer and a solid layer of material are formed in the upper and lower portions of a

crucible, respectively. In the method of Kobayashi, the volume of melted material is adjusted as the crystal is pulled from the melt according to the non-segregation condition using a variable-thickness melted layer method. (See, for example, the Abstract in Kobayashi.) The disclosure of Kobayashi clearly distinguishes between methods for growing a single crystal based on a constant-thickness melted layer method and a variable-thickness melted layer method. Specifically, the disclosure of Kobayashi states:

> "In the constant-thickness melted layer method, the heater 2 is controlled during the pulling process so that the reduction of molten liquid caused by the pulling of a single crystal can be replenished by melting the solid layer S in order to keep the thickness of the melted layer L constant and maintain the impurity concentration in the axial direction of single crystal more uniformly than the CZ method. . . . By contrast, in the variable-thickness melted layer method, the volume of the melted layer L is intentionally varied so that the impurity concentration in the axial direction of single crystal can be maintained at a constant value. The variable-thickness melted layer method is superior to the constant-thickness melted layer method from the viewpoint of realizing the non-segregation condition without the adding of impurity during the growing period."

Thus, in the variable thickness method taught by Kobayashi, the melting of a pure silicon solid feed is controlled in order to provide a melt layer having a constant concentration of dopant. Based on this principle of operation, there would be no reason to include the dopant material in the solid feed itself. In fact, the addition of the dopant to the solid feed would interfere with the theory of operation behind the variable-thickness melted layer method of Kobayashi. For this reason, Kobayashi does not support an obviousness rejection under 35 U.S.C. § 103(a), and Applicants respectfully request that the Examiner withdraw the objection.

V. Conclusion

In view of the foregoing remarks, Applicants respectfully request that the Examiner reconsider and withdraw the pending rejections discussed above. Applicants also solicit an early notification of allowance. If Examiner Song has any questions, or believes a

telephone discussion would expedite the prosecution of this application, he is invited to contact the undersigned.

Respectfully submitted,

Date October 23, 2002

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Amended Claims With Markings to Show Changes

13. A method of carrying out Czochralski crystal growth comprising:

(a) providing a crucible with a solid feed material therein**[having a desired concentration of]**, **the solid feed material comprising each of the** constituents **[for]**of the crystal to be grown;

(b) heating an upper portion of the crucible with an upper heater to a temperature sufficient to melt the feed material in an upper portion of the crucible and separately heating a lower portion of the crucible with a lower heater to another temperature which is below the melt temperature of the feed material so that the feed material in the lower portion of the crucible remains solid;

(c) growing a crystal from the melt and drawing the growing crystal out of the melt; **and**

(d) advancing the crucible with respect to the heaters as the crystal is drawn from the melt to heat additional portions of solid feed material with the upper heater to melt the additional solid material to replace the crystal drawn from the melt.

21. The method of Claim 13 wherein the step of providing a crucible with a solid feed material therein includes filling the crucible with a mixture of **[particulate]** feed material **[having]**comprising each of the**[desired concentration of]** constituents **of the crystal to be grown**, heating the **mixture [particulate material]**to melt it in the crucible and **[thoroughly]**mixing the melted **mixture[material]**, then freezing the melted **mixture [material]**to form a solid feed material in the crucible, and then heating an upper portion of the feed material in the crucible with the upper heater to a temperature above the melting temperature of the material.

26. The method of Claim 13 wherein before drawing the crystal from the melt, the melt is leveled by the addition of a **[desired]**dopant **or a constituent of an alloy** to adjust the melt concentration to a level **of** C_o/k, where C_o is the **[desired dopant]**concentration **of the dopant or the constituent of the alloy** in the crystal and k is an experimentally determined constant.

29. A method of carrying out liquid encapsulated Czochralski crystal growth comprising:

(a) providing a crucible with a solid feed material therein[**having a desired concentration of**]**, the solid feed material comprising each of the** constituents **[for]of** the crystal to be grown;

(b) heating an upper portion of the crucible with an upper heater to a temperature sufficient to melt the feed material in an upper portion of the crucible and separately heating a lower portion of the crucible with a lower heater to another temperature which is below the melt temperature of the feed material so that the feed material in the lower portion of the crucible remains solid;

(c) growing a crystal from the melt and drawing the growing crystal out of the melt while covering the melt with a liquid encapsulant material; **and**

(d) advancing the crucible with respect to the heaters as the crystal is drawn from the melt to heat additional portions of solid feed material with the upper heater to melt the additional solid material to replace the crystal drawn from the melt.

36. The method of Claim 29 wherein before drawing the crystal from the melt, the melt is leveled by the addition of a **[desired]**dopant **or a constituent of an alloy** to adjust the melt concentration to a level **of** C_o/k, where C_o is the **[desired dopant]**concentration **of the dopant or the constituent of the alloy** in the crystal and k is an experimentally determined constant..

37. The method of Claim 29 wherein the step of providing a crucible with a solid feed material therein includes filling the crucible with a mixture of **[particulate]**feed material **[having]comprising each of** the**[desired concentration of]** constituents **of the crystal to be grown** and the encapsulant, heating the **mixture [particulate material]**to melt it in the crucible and **[thoroughly]**mixing the melted **mixture[material]**, then freezing the melted **mixture [material]**to form a solid feed material in the crucible, and then heating an upper portion of the feed material in the crucible with the upper heater to a temperature above the melting temperature of the material.